Remarks on semileptonic B and D decays into orbitally excited mesons

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Abstract

We have obtained the differential decay rate and calculated the branching ratios of the exclusive semileptonic decays $B(D) \to Xl\nu$, where X is a p-wave meson, using the nonrelativistic ISGW quark model. Our results are compared with the predictions of the ISGW2 model. We have computed some branching ratios that were not reported or were reported with 0.00 in this model. For example, we find that $Br(B_c^- \to \overline{B_{s2}^{*0}} l^- \overline{\nu}) = 4.03 \times 10^{-5}$, $Br(B_c^- \to \overline{B_2^{*0}} l^- \overline{\nu}) = 3.65 \times 10^{-6}$ and $Br(D_s^+ \to f_2 l^+ \nu) = 2.7 \times 10^{-5}$, which seems to be at the reach of forthcoming experiments. Furthermore, we have classified the $B_{u,d,s} \to Tl\nu$ decays in two groups and compared the semileptonic and nonleptonic decays including a tensor meson in the final state.

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1. **Introduction**

We have calculated the differential decay rates and the numerical values of the branching ratios of the semileptonic decays $B(D) \to Xl\nu$, where X is an orbitally excited meson ${}^3P_2$ (i.e., a tensor meson T) or ${}^1P_1$, in the nonrelativistic quark model of Isgur-Scora-Grinstein-Wise (ISGW model) [1]. Specifically, we have considered exclusive semileptonic decays of the mesons B_q ($q = u, d, s, c$) and $D_{q'}$ ($q' = u, d, s$). Let us mention that the ISGW model [1] shows the inclusive spectrum of the semileptonic B and D decays. So, in this work we have obtained the branching ratios to each exclusive channel and compared them with the predictions of the ISGW2 model [2]. We have computed some branching ratios that do not appear or appear with 0.00 in this model [2]. From our results we can classify the $B_{u,d,s} \to Tl\nu$ decays in two groups and establish a connection between $B \to Tl\nu$ and $B \to TV$ (V means a vector meson), which agrees with the Bjorken′s relation if we ignore the nonfactorizable contributions.

Semileptonic B decays have been studied widely. The current experimental data show that semileptonic B decays to ground charmed mesons (D and D^*) is approximately the 60% of the inclusive semileptonic decay rate [3]-[5] and that the remainder 40% should go to excited charmed mesons and nonresonant final states [3]-[6]. Besides, the semileptonic B decays into p-wave charm mesons are the main background in the measurement of the $Br(B \to D^* l\nu)$ [7]-[9]. For these reasons, the production of orbitally excited charmed mesons (or p-wave charmed states) in semileptonic B decays is an interesting area of research and has been studied in the literature in the frame of Heavy Quark Effective Theory (HQET) [3], [5], [10]-[13] and quark models [1], [2], [14]-[16].

There are four orbitally excited charmed states with $l = 1$, which can be classified in two doublets: (D_0, D_1^*) and (D_1, D_2^*) with $j = 1/2$, $J^P = (0^+, 1^+)$ and $j = 3/2$, $J^P = (1^+, 2^+)$, respectively. In this work, we have studied, additional to the semileptonic B decays with charmed mesons $B \to D_1(2420)l\nu$ and $B \to D_2^*(2460)l\nu$, all the exclusive channels $B_{u,d,s,c} \to Tl\nu$, where T is a ${}^3P_2$ orbitally excited tensor meson. Let us point out that the ISGW model works well for the B_c decays since it is conformed by two heavy quarks.

The Heavy Quark Effective Theory is not an appropiate scenario when the two constituent quarks inside the meson are heavy [17].

Furthermore, we have computed the branching ratios of the semileptonic decays $D \to Tl\nu$. In this case, there is not enough theoretical and experimental information about them. The most of the branching ratios of these decays were reported with 0.00 in the Ref. [2]. We think that forthcoming experiments at CLEO-c Project will allow to test some of these predictions in the nonrelativistic quark models [1, 2].

2. **Differential decay rate of semileptonic decays with orbitally excited mesons in the final state**

Integrating the expression for $d^2\Gamma(P \to Xl\nu)/dxdy$, given in the ISGW model [1], we have obtained the differential decay rate of any semileptonic decay of a pseudoscalar meson P,

$$\frac{d\Gamma(P \to Xl\nu)}{dt} = \frac{\left|V_{qq'}\right|^2 G_F^2}{32\pi^3 m_P^2} \left|\vec{P}_X\right| \left(\frac{4}{3} m_P^2 \beta_{++} \left|\vec{P}_X\right|^2 + \alpha t\right), \tag{1}$$

where $t = (p_P - p_X)^2$, $\vec{P}_X$ is the three-momentum of X in the P rest frame, G_F is the Fermi constant, $V_{qq'}$ is the Cabibbo-Kobayashi-Maskawa (CKM) factor and β_{++} and α are functions of the form factors [1]. In the above equation $m_l \approx 0$ i.e., $l = e, \mu$.

Using the corresponding expressions for the functions β_{++} and α given in the appendix of the Ref. [1] when X is an orbitally excited meson ${}^1P_1$, we obtain explicitly, from the Eq. (1), the following differential decay rate of the semileptonic decay $B \to ({}^1P_1)l\nu$:

$$\begin{aligned}\frac{d\Gamma(B \to Xl^-\overline{\nu})}{dt} &= \frac{\left|V_{qb}\right|^2 G_F^2}{96\pi^3 m_X^2} \left\{4m_B^2 S_+^2 \left|\vec{P}_X\right|^5 + \left[r^2 + 8m_X^2 t v^2 + 2(m_B^2 - m_X^2 - t) r S_+\right] \left|\vec{P}_X\right|^3 \right. \\ &\quad \left. + \frac{3m_X^2}{m_B^2} t r^2 \left|\vec{P}_X\right| \right\}, \end{aligned} \tag{2}$$

where S_+, r and v are form factors given in the Ref. [1] and X is a $p-wave$ meson ${}^1P_1$.

On the other hand, we have taken from the appendix of the Ref. [1] the corresponding expressions of the functions β_{++} and α assuming that X is an orbitally excited $^3P_2$ tensor meson T. In this case, we have obtained explicitly the following expression for the semileptonic decay rate of $B \to Tl\nu$

$$\frac{d\Gamma(B \to Tl\nu)}{dt} = \frac{|V_{qb}|^2 G_F^2}{288\pi^3 m_T^4} \left\{ \alpha(t) \left|\vec{P}_T\right|^7 + \beta(t) \left|\vec{P}_T\right|^5 + \gamma(t) \left|\vec{P}_T\right|^3 \right\}, \tag{3}$$

where $\alpha(t)$, $\beta(t)$ and $\gamma(t)$ are quadratic functions of the form factors b_+, k and h, given by

$$\begin{aligned} \alpha(t) &= 8m_B^4 b_+^2, \\ \beta(t) &= 2m_B^2 \left[6m_T^2 t h^2 + k^2 + 2(m_B^2 - m_T^2 - t)kb_+ \right], \\ \gamma(t) &= 5m_T^2 t k^2. \end{aligned} \tag{4}$$

From Eqs. (2) and (3) we can see that the decay width of the semileptonic decay $B(D) \to Xl\nu$, where X is an orbitally excited meson $^1P_1$ or $^3P_2$ (a tensor meson T) has three contributions. In one case, for $X = {}^1P_1$, these contributions are proportional to $|\vec{P}_X|^5$, $|\vec{P}_X|^3$ and $|\vec{P}_X|$. On the other hand, when X is a tensor meson T, they are proportional to $|\vec{P}_T|^7$, $|\vec{P}_T|^5$ and $|\vec{P}_T|^3$ (we call these contributions $\Gamma_{(7)}$, $\Gamma_{(5)}$ and $\Gamma_{(3)}$, respectively). It means that the particles in the final state are coupled to waves $l = 2, 1, 0$ or $l = 3, 2, 1$ when the orbitally excited meson is $^1P_1$ or $^3P_2$, respectively[1].

Now, we are going to compare at tree level the semileptonic decay $B(b\overline{q}) \to T(q'\overline{q})l\nu$ with the *type-I* nonleptonic decay $B(b\overline{q}) \to T(q'\overline{q})V(q_i\overline{q_j})$, which are produced by the current matrix element $< T|J_\mu|B >$ (i.e. the tensor meson T is produced from the transition $B \to T$). If we suppose that the only factorizable contribution to $B \to TV$ comes from $< T|J_\mu|B >< V|J^\mu|0 >$ and neglect the nonfactorizable contributions, we can establish a ratio between the Eq. (3) and the Eq. (11) of the Ref. [18]. It is given by

[1]We display in the table 2 the contributions $\Gamma_{(7)}$, $\Gamma_{(5)}$ and $\Gamma_{(3)}$ to the decay width of each exclusive channel $B \to Tl\nu$.

$$\mathcal{R} \equiv \frac{\Gamma(B \to TV)}{\left.\frac{d\Gamma(B\to Tl\nu)}{dt}\right|_{t=m_V^2}} = 6\pi^2 \left|V_{ij}\right|^2 a_1^2 F_V^2, \tag{5}$$

where $F_V = m_V f_V$ is the decay constant (f_V is adimensional in this case), V_{ij} is the appropiate CKM factor (depending on the flavor quantum numbers of the meson V) and a_1 is the QCD coefficient.

In the literature, neglecting nonfactorizable contributions to the decay amplitude, is well known that an identical expression is obtained for the ratio $\mathcal{R}$ when we compare the decays $B \to Xl\nu$ and $B \to XV$, X being a pseudoscalar (P) or a vector (V) meson and arising from the transition $B \to X$. Therefore, we would like to point out that in this work we show explicitly that the ratio $\mathcal{R} = 6\pi^2 \left|V_{ij}\right|^2 a_1^2 F_V^2$ between $B \to Xl\nu$ and $B \to XV$ is always the same irrespective of the meson X is a pseudoscalar, a vector or a tensor meson. It means that the production of the lepton pair in the semileptonic decay is kinematically equivalent to the production of a pseudoscalar or a vector [7, 19] or a tensor meson in the nonleptonic decay. It is important to note that the expression for $\mathcal{R}$, which is independent of the model, also agrees with the Bjorken$'$s relation [7, 19, 20] and it provides a clear test of the factorization hypothesis and may be employed to determine unknown decay constants [7, 19].

3. Numerical values

In this section we calculate the branching ratios of the exclusive semileptonic decays $B_q(D_{q'}) \to Tl\nu$, where T is an orbitally excited meson ${}^3P_2$, $q = u, d, s, c$ and $q' = u, d, s$, and $B^-(\overline{B_s^0}) \to D_1^0(D_{s1}^+)l^-\overline{\nu}$ using the ISGW model [1]. In order to provide numerical values of the branching ratios of $B \to {}^1P_1 l\nu$ and $B(D) \to Tl\nu$ we use the expressions for the differential decay rates given in Eqs. (2) and (3), respectively, and the following values of the CKM elements [21]: $|V_{cb}| = 0.0402$, $|V_{ub}| = 3.3 \times 10^{-3}$, $|V_{cs}| = 0.97$, $|V_{cd}| = 0.224$. The values for the lifetime of $B_{u,d,s,c}$ and $D_{u,d,s}$ and all the masses required are taken form [21]. We have used an octet-singlet mixing angle $\theta_T = 28^\circ$ when we computed the decays that involve an isoscalar tensor meson f_2 or f_2'.

In the table 1 we present our results (see the second column) for the branching ratios of $B \to Tl\nu$ and $B^-(\overline{B_s^0}) \to D_1^0(D_{s1}^+)l^-\overline{\nu}$ (D_1^0 and D_{s1} are ${}^1P_1$ mesons). In the third (fourth) column we display the values obtained from the ISGW2 model [2] (other references in the frame of quark models or HQET). We can see that, in general, the values obtained in the ISGW model [1] are smaller than the values obtained in the ISGW2 model [2]. A similar conclusion was obtained recently by [22] working with nonleptonic two-body B decays. The experimental values of CLEO [21, 23] $Br(B^- \to D_2^{*0}l^-\overline{\nu}) < 8 \times 10^{-3}$ and $Br(B^- \to D_1^0 l^-\overline{\nu}) = (5.6 \pm 1.6) \times 10^{-3}$ agree with all the predictions obtained from the quark models [1, 2, 14, 16] and the HQET [3, 11, 12].

Let us mention that we obtain $\mathcal{R} = [Br(B^- \to D_2^{*0}l^-\overline{\nu})/Br(B^- \to D_1^0 l^-\overline{\nu})] = 0.3539$ which is consistent with the experimental limit $\mathcal{R} < 1.42$ [21] and the report of the Ref. [8]. On the other hand the sum of all the branching ratios of $B_{u,d} \to Xl\nu$ (where X is an orbitally excited meson), calculated in this work (see the second column in the table 1), is almost 0.745% (i. e. 1.49% including the conjugate channels).

In the table 2 we show the three contributions $\Gamma_{(7)}$, $\Gamma_{(5)}$ and $\Gamma_{(3)}$, given by the Eq. (3), to the decay width of $B \to Tl\nu$. We note that the $B_{u,d,s} \to Tl\nu$ decays can be classified in two groups. In one of them, all the contributions are positive and the contribution $\Gamma_{(3)}$, which is proportional to $|\vec{P}_T|^3$ is the largest. The decays which come from the $b \to u$ transition are in the other group. In this case, the contribution $\Gamma_{(7)}$, which is proportional to $|\vec{P}_T|^7$, is the largest and the contribution $\Gamma_{(5)}$, which is proportional to $|\vec{P}_T|^5$, is negative. For $B_c \to Tl\nu$ these contributions, in all the cases, are positive and $\Gamma_{(3)}$ is the largest.

Finally, in the table 3 we show the numerical values of the branching ratios for the decays $D_{q'} \to Tl\nu$ ($q' = u, d, s$). In this case there is not enough theoretical predictions and experimental data. So, we have only compared our results with the ISGW2 model [2]. The most of the branching ratios were reported with 0.00 in this Ref. [2]. The $Br(D^0 \to a_2^- l^+\nu)$ and $Br(D_s^+ \to K_2^{*0}l^+\nu)$ are enhanced by about an order of magnitude in the ISGW2 model. Our prediction for $Br(D^+ \to \overline{K_2^{*0}}l^+\nu)$ is below three orders of magnitude of the experimental limit ($< 8 \times 10^{-3}$) [21]. Let us mention that we do not display the contributions $\Gamma_{(7)}$, $\Gamma_{(5)}$

and $\Gamma_{(3)}$, given by the Eq. (3), to $\Gamma(D \to Tl\nu)$ because their behaviour is similar to the case of $B_c \to Tl\nu$ decays.

4. Conclusion

We have computed the branching ratios of the semileptonic B and D decays involving $^1P_1$ and $^3P_2$ mesons in the final state (they are p-wave orbitally excited mesons) using the nonrelativistic quark ISGW model [1]. We have calculated some branching ratios that were not predicted or were reported with 0.00 or in the Ref. [2]. For example, we have found that $Br(B_c^- \to \overline{B_{s2}^{*0}} l^- \overline{\nu}) = 4.03 \times 10^{-5}$, $Br(B_c^- \to \overline{B_2^{*0}} l^- \overline{\nu}) = 3.65 \times 10^{-6}$ and $Br(D_s^+ \to f_2 l^+ \nu) = 2.7 \times 10^{-5}$, which seems to be within the reach of forthcoming experiments. In general, the branching ratios predicted by the ISGW model are smaller than the predictions of the ISGW2 model. At this time, the predictions for $B^- \to D_2^{*0} l^- \overline{\nu}$ and $B^- \to D_1^0 l^- \overline{\nu}$ from the quark models and HQET agree with the experimental data.

The decays $B_{u,d,s} \to Tl\nu$ can be classified in two groups, depending on the contributions Γ_7, Γ_5 and Γ_3, given by the Eq. (3), to the decay width. We also establish a relation between the semileptonic decay $B \to Tl\nu$ and the nonleptonic decay $B \to TV$, neglecting the nonfactorizable and the annihilation contributions.

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Process	This work	ISGW2 [2]	Other Refs.
$B^- \to D_2^{*0} l^- \overline{\nu}$	1.56×10^{-3}	2.4×10^{-3}	$5.2(5.9) \times 10^{-3}$ $m_Q \to \infty$ $(1/m_Q)$ [3, 12]
			$(7 - 4.7 - 6.5 - 7.7) \times 10^{-3}$ [16]
			$(7.9 \pm 2.3) \times 10^{-3}$ [11]
			5.2×10^{-3} [14]
$B^- \to a_2^0 l^- \overline{\nu}$	6.31×10^{-6}	2.88×10^{-5}	
$B^- \to f_2 l^- \overline{\nu}$	5.32×10^{-6}	3.24×10^{-5}	
$B^- \to f_2' l^- \overline{\nu}$	9.56×10^{-7}		
$\overline{B^0} \to D_2^{*+} l^- \overline{\nu}$	1.46×10^{-3}	2.25×10^{-3}	
$\overline{B^0} \to a_2^+ l^- \overline{\nu}$	1.18×10^{-5}	5.56×10^{-5}	
$\overline{B_s^0} \to D_{s2}^{*+} l^- \overline{\nu}$	1.76×10^{-3}	3.13×10^{-3}	5.9×10^{-3} [14]
$\overline{B_s^0} \to K_2^{*+} l^- \overline{\nu}$	6.61×10^{-6}	4.55×10^{-5}	
$B_c^- \to \chi_{c2} l^- \overline{\nu}$	6.07×10^{-4}	8.17×10^{-4}	$1.407(1.909) \times 10^{-3}$ [24]
$B_c^- \to \overline{D_2^{*0}} l^- \overline{\nu}$	7.57×10^{-7}	3×10^{-6}	
$B_c^- \to \overline{B_{s2}^{*0}} l^- \overline{\nu}$	4.03×10^{-5}	0.00	
$B_c^- \to \overline{B_2^{*0}} l^- \overline{\nu}$	3.65×10^{-6}		
$B^- \to D_1^0 l^- \overline{\nu}$	4.407×10^{-3}	4.8×10^{-3}	$3.4(13) \times 10^{-3}$ $m_Q \to \infty$ $(1/m_Q)$ [3, 12]
			$(4.5 - 2.9 - 4.2 - 4.9) \times 10^{-3}$ [16]
			$(4.5 \pm 1.3) \times 10^{-3}$ [11]
			3.3×10^{-3} [14]
$\overline{B_s^0} \to D_{s1}^+ l^- \overline{\nu}$	1.95×10^{-3}	5.3×10^{-3}	3.9×10^{-3} [14]

Table 1. Branching ratios of the semileptonic B decays with orbitally excited mesons $^3P_2$ and $^1P_1$ (see the last two processes).

Process	$\Gamma_{(7)}$	$\Gamma_{(5)}$	$\Gamma_{(3)}$
$B^- \to D_2^{*0} l^- \overline{\nu}$	1.2627	1.4648	3.4873
$B^- \to a_2^0 l^- \overline{\nu}$	4.8092×10^{-2}	-3.4228×10^{-2}	1.1283×10^{-2}
$B^- \to f_2 l^- \overline{\nu}$	4.1825×10^{-2}	-3.0097×10^{-2}	9.4626×10^{-3}
$B^- \to f_2' l^- \overline{\nu}$	6.3540×10^{-3}	-4.2931×10^{-3}	1.747×10^{-3}
$\overline{B^0} \to D_2^{*+} l^- \overline{\nu}$	1.2638	1.4646	3.4893
$\overline{B^0} \to a_2^+ l^- \overline{\nu}$	9.6234×10^{-2}	-6.8486×10^{-2}	2.2575×10^{-2}
$\overline{B_s^0} \to D_{s2}^{*+} l^- \overline{\nu}$	1.1022	2.3838	4.3102
$\overline{B_s^0} \to K_2^{*+} l^- \overline{\nu}$	2.3412×10^{-2}	-1.2501×10^{-2}	1.8244×10^{-2}
$B_c^- \to \chi_{c2} l^- \overline{\nu}$	4.3443×10^{-1}	3.0763	5.1773
$B_c^- \to \overline{D_2^{*0}} l^- \overline{\nu}$	6.7408×10^{-4}	2.1651×10^{-3}	8.0017×10^{-3}
$B_c^- \to \overline{B_{s2}^{*0}} l^- \overline{\nu}$	2.3402×10^{-3}	2.5878×10^{-1}	3.1576×10^{-1}
$B_c^- \to \overline{B_2^{*0}} l^- \overline{\nu}$	3.0461×10^{-4}	2.2567×10^{-2}	2.9442×10^{-2}

Table 2. Contributions to $\Gamma(B \to T l \nu)$ proportional to $|\vec{P}_T|^7$, $|\vec{P}_T|^5$ and $|\vec{P}_T|^3$. All the values must be multiplied by 10^{-16}.

Process	This work	ISGW2 [2]
$D^+ \to \overline{K_2^{*0}} l^+ \nu$	7×10^{-6}	0.00
$D^+ \to a_2^0 l^+ \nu$	5.8×10^{-7}	0.00
$D^+ \to f_2 l^+ \nu$	7.65×10^{-7}	0.00
$D^+ \to f_2' l^+ \nu$	4.72×10^{-9}	
$D^0 \to K_2^{*-} l^+ \nu$	2.86×10^{-6}	0.00
$D^0 \to a_2^- l^+ \nu$	4.32×10^{-7}	2.07×10^{-6}
$D_s^+ \to f_2 l^+ \nu$	2.7×10^{-5}	
$D_s^+ \to f_2' l^+ \nu$	4.03×10^{-6}	0.00
$D_s^+ \to K_2^{*0} l^+ \nu$	6.16×10^{-7}	2.48×10^{-6}

Table 3. Branching ratios of the decays $D \to T l \nu$.

References

[1] N. Isgur, D. Scora, B. Grinstein and M. B. Wise, Phys. Rev. D **39**, 799 (1989).

[2] D. Scora and N. Isgur, Phys. Rev. D **52**, 2783 (1995).

[3] M-Q. Huang and Y-B. Dai, Phys. Rev. D **64**, 014034 (2001).

[4] D. Ebert, R. N. Faustov and V. O. Galkin, `e-print hep-ph/0101301`.

[5] A. K. Leibovich, Z. Ligeti, I. W. Stewart and M. B. Wise, Phys. Rev. Lett. **78**, 3995 (1997); Phys. Rev. D **57**, 308 (1998).

[6] P. S. Drell, `e-print hep-ex/9711020`; M. B. Wise, Nucl. Instrum. Meth. A **408**, 1 (1998).

[7] *The BaBar Physics Book*, P. F. Harrison and H. R. Quinn (eds.), babar504 (1998).

[8] M. Battaglia, `e-print hep-ph/0102170`.

[9] M. Di Pierro and A. K. Leibovich, `e-print hep-ph/0207134`.

[10] N. Isgur and M. B. Wise, Phys. Rev. D **43**, 819 (1991)

[11] W. Y. Wang and Y. L. Wu, Int. J. Mod. Phys. A **16**, 2505 (2001).

[12] Y-B. Dai and M-Q. Huang, Phys. Rev. D **59**, 034018 (1999).

[13] M. Matsuda and T. B. Suzuki, Phys. Lett. B **380**, 371 (1996).

[14] D. Ebert, R. N. Faustov and V. O. Galkin, Phys. Lett. B **434**, 365 (1998).

[15] A. Wambach, Nucl. Phys. B **434**, 647 (1995).

[16] V. Morénas *et al.*, Phys. Rev. D **56**, 5668 (1997).

[17] T. Mannel and S. Wolf, Phys. Rev. D **65**, 074012 (2002); C. Q. Geng, C. W. Hwang and C. C. Liu, Phys. Rev. D **65**, 094037 (2002); C-H. Chang, S-L. Chen, T-F. Feng and X-Q. Li, Commun. Theor. Phys. **35**, 51 (2001).

[18] G. López Castro and J. H. Muñoz, Phys. Rev. D **55**, 5581 (1997).

[19] M. Neubert and B. Stech, in *Heavy Flavors*, 2nd ed., edited by A. J. Buras and M. Lindner (World Scientific, Singapore, 1998) (`e-print hep-ph/9705292`).

[20] J. D. Bjorken, Nucl. Phys. B (Proc. Suppl.) **11**, 325 (1989); M. Neubert, Phys. Lett. B **418**, 173 (1998); Z. Luo and J. L. Rosner, Phys. Rev. D **65**, 054027 (2002).

[21] Particle Data Group, D. E. Groom *et al.*, Eur. Phys. J. C **15**, 1 (2000).

[22] C. S. Kim, J-P. Lee and S. Oh, `e-print hep-ph/0205263`.

[23] CLEO Collaboration, A. Anastassov *et al.*, Phys. Rev. Lett. **80**, 4127 (1998).

[24] C-H. Chang, Y-Q. Chen, G-L. Wang and H-S. Zong, Phys. Rev. D **65** 014017 (2002) ; C-H. Chang, `e-print hep-ph/0205112`.